

Commercial Building Energy Alliance Technical Specification

Electric Storage Water Heaters

Space Conditioning Project Team

Version 1.0

February 29, 2012

Summary

This draft specification provides a description of performance characteristics for high-efficiency commercial electric storage water heaters. Electric storage water heaters are used in a variety of commercial buildings, including food service establishments, schools, and offices, especially where gas is unavailable. The final specification will be developed with Commercial Building Energy Alliance (CBEA) member and manufacturer input and include minimum requirements that will be of interest to a critical number of CBEA members.

This draft specification is not intended to be a comprehensive purchase specification. It is intended to supplement a purchase specification by outlining energy-related product requirements.

1. Acronyms and Definitions

Coefficient of performance (COP) – The ratio of heat input provided to the water compared to the total power input.

*Commercial Storage Water Heater*¹ – a water heater that heats and stores water within the appliance at a thermostatically controlled temperature for delivery on demand and that is industrial equipment; such term does not include units with an input rating of 4,000 Btu/hr or more per gallon of stored water.

Heat Pump Water Heater (HPWH) – A water heater that uses electricity to transfer heat from cooler location to hotter ones.

Integrated Heat Pump Water Heater – a HPWH that is sold by the manufacturer with an insulated storage tank as a packaged unit.

Modular Heat Pump Water Heater – a HPWH that is not sold with a tank, but intended to be installed with one or more storage-type tanks that are properly sized for the heat pump, according to manufacturer guidelines.

*Residential Electric Storage Water Heater*² – a water heater that uses electricity as the energy source, is designed to heat and store water at a thermostatically controlled temperature of less than 180 °F (82 °C), has a nominal input of 12 kilowatts (40,956 Btu/h) or less, and has a rated storage capacity of not less than 20 gallons (76 liters) nor more than 120 gallons (450 liters).

¹ As defined in: [Subpart G of CFR Part 431 – Commercial Water Heaters, Hot Water Supply Boilers and Unfired Hot Water Storage Tanks](#).

² As defined in: [Appendix E to Subpart B of CFR Part 430 – Uniform Test Method for Measuring the Energy Consumption of Water Heaters](#).

2. Specification Scope

2.1. Covered Equipment

This specification applies to electric storage water heaters that meet all of the following criteria:

- Meet the above definition of a *commercial storage water heater*.
- Use electricity as the sole energy source.
- Do not meet the above definition of *residential electric storage water heaters* (i.e., the nominal heat inputs greater than 12 kW (40,956 Btu/h) and/or the rated storage tank volume exceeds 120 gallons).

2.2. Non-Covered Equipment

The specification does not cover residential electric storage water heaters (i.e., nominal input of 12 kW (40,956 Btu/h) or less; rated storage volume from 20 to 120 gallons).

2.3. Relevant Codes, Standards, or Specifications

This specification builds on the following current energy conservation standard:

- [Subpart G of CFR Part 431 – Commercial Water Heaters, Hot Water Supply Boilers and Unfired Hot Water Storage Tanks.](#)

3. Energy-Efficiency Requirements

3.1. Heat Pump Water Heater Requirement & HPWH COP Test Method

The electric storage water heater shall use an air-to-water heat pump as the primary heat source, in either of the following configurations:

- The heat pump could be included with the storage tank (subject to requirements in Section 2.2) as an *integrated* HPWH.
- The heat pump could be a *modular*, to be combined with a storage-type tank that is properly sized for the heat pump, according to manufacturer guidelines.

A second electric or gas storage water heater may be used in series, downstream of the heat pump water heater.

The energy efficiency of the integrated or modular HPWH shall be tested using the draft AHRI Standard 1301P (I-P)³ and the heat pump shall have a minimum COP of 4.2.

Question: *Is 4.2 COP the appropriate efficiency?*

3.2. Standby Loss Requirement & Test Method

Integrated HPWHs shall conform to the current energy conservation standard⁴:

Maximum Standby Loss: $0.30 + 27/V_m$ (%/hr), where V_m is the measured volume.

Water heaters having more than 140 gallons of storage capacity need not meet the standby loss requirement if the tank surface area is thermally insulated to R-12.5 or more.

The standby loss shall be measured according to Section 2.10 of ANSI Z21.10.3-1998.

4. Other Requirements

4.1. Condensate Management

Condensate must be collected so that it can be drained according to local plumbing codes.

4.2. Heat Pump Failure Alarm

The HPWH shall include an alarm to indicate heat pump failure.

Question: *Are these requirements sufficiently descriptive or should more detail be specified in terms of the nature of the alarm?*

Question: *Are there any other features that should be included in this specification*

5. Warranty Requirements

The model will carry a warranty having minimum periods of:

- One year from date of purchase covering manufacturer defects on parts.
- Five years from date of purchase covering manufacturer defects on the compressor.
- If the model includes a storage tank, three years from the date of purchase covering leakage due to corrosion of the tank.

Question: *Are these warranty periods appropriate?*

³ This requirement was added under the presumption that AHRI Standard 1301P (I-P), “Performance Rating of Commercial Heat Pump Water Heaters”, would be published by September, 2012.

⁴ As defined in: [Subpart G of CFR Part 431 – Commercial Water Heaters, Hot Water Supply Boilers and Unfired Hot Water Storage Tanks](#).

6. References

- a. [Appendix E to Subpart B of CFR Part 430 – Uniform Test Method for Measuring the Energy Consumption of Water Heaters](#)
- b. [Subpart G of CFR Part 431 – Commercial Water Heaters, Hot Water Supply Boilers and Unfired Hot Water Storage Tanks](#)
- c. AHRI Standard 1301P (I-P) – Performance Rating of Commercial Heat Pump Water Heaters
- d. ANSI Z21.10.3-1998 – American National Standard/CSA Standard for Gas Water Heaters
- e. A Specification for Residential Heat Pump Water Heaters Installed in Northern Climates Version 4.0 (NEEA, 2011)

Appendix A: Example Full System Specification

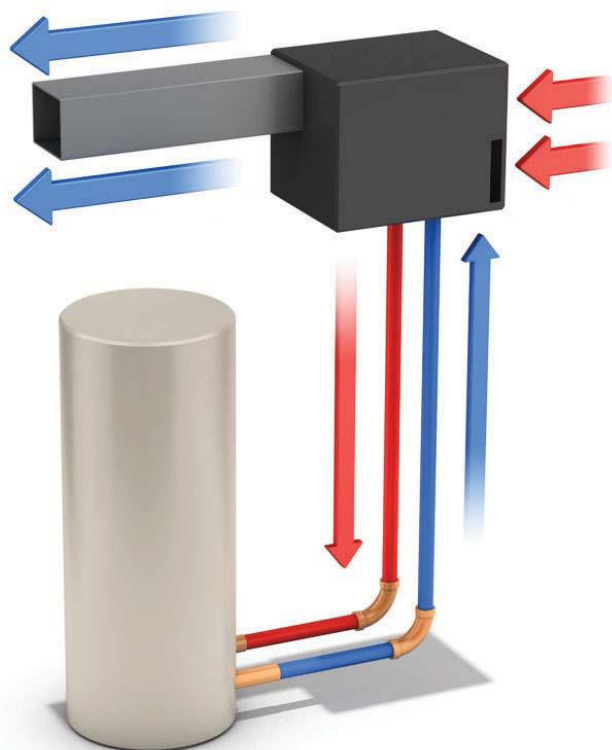
Note: The full system specification will be developed once energy guidelines are finalized.

DRAFT

Appendix B: Accompanying Document and Energy Savings Analysis

Note: Included as an attachment

DRAFT



Sources: A.O. Smith

Electric Storage Water Heaters

Supplementary Information for Technical
Specification

February 29, 2012

- 1 » Technology Specification Overview**
- 2 » Market Analysis
- 3 » Specification Analysis

With assistance from CBEA members, DOE is pursuing technology specifications to help pull innovative, energy-saving technologies to market.

- This report supplements the technology specification for **Electric Storage Water Heaters**.
- Electric Storage Water Heaters are found on commercial buildings in many CBEA sectors including food services, education, offices, etc.

- 1 » Technology Specification Overview
- 2 » Market Analysis**
- 3 » Specification Analysis

This specification applies to electric storage water heaters that meet all of the following criteria:

- Meet the definition of a *commercial* storage water heater¹:
 - Heats and stores water within the appliance at a thermostatically controlled temperature for delivery on demand;
 - Is industrial equipment;
 - This definition does not include units with an input rating of 4,000 Btu/hr or more per gallon of stored water.
- Use electricity as the primary energy source.
- Do not qualify as *residential* electric storage water heaters² because of either of the following reasons:
 - The nominal heat input exceeds 12 kW (40,956 Btu/h);
 - The rated storage tank volume exceeds 120 gallons.

¹ As defined in: [Appendix E to Subpart B of CFR Part 430 – Uniform Test Method for Measuring the Energy Consumption of Water Heaters](#).

² As defined in: [Subpart G of CFR Part 431 – Commercial Water Heaters, Hot Water Supply Boilers and Unfired Hot Water Storage Tanks](#).

For this specification, we propose the use of a heat pump water heaters (HPWHs), in either of the following configurations:

- The heat pump could be included with the storage tank as an *integrated* HPWH (storage tank included, subject to DOE standby loss requirements).
- The heat pump could be *modular*, connected in the field to a storage-type tank that is properly sized for the heat pump, according to manufacturer guidelines.

A second electric or gas storage water heater is generally placed in series, downstream of the first tank, to provide supplemental heating.

For electric storage water heaters, the efficiency metrics are coefficient of performance (COP) and standby loss.

- Coefficient of performance¹ – A ratio of the heating capacity in kW , to the power input value in kW at a given set of rating conditions expressed in kW/kW.
- While COP is helpful for comparing HPWHs, it is not representative of field performance due to supplemental heating in the field (i.e., with a secondary electric or gas storage water heater).
- Standby loss² – the average hourly energy required to maintain the stored water temperature, expressed as a percentage (per hour) of the heat content of the stored water.

¹ As defined in AHRI Standard 1301P (I-P), “Performance Rating of Commercial Heat Pump Water Heaters”, which is expected to be published by September, 2012.

² As defined in: [Subpart G of CFR Part 431 – Commercial Water Heaters, Hot Water Supply Boilers and Unfired Hot Water Storage Tanks](#).

There is currently no universally accepted test procedure for commercial HPWH.

- AHRI is developing a test procedure¹ for commercial HPWHs, expected to be published by September, 2012.
- There is a DOE test procedure to verify standby loss in electric storage water heaters that references Section 2.10 of ANSI Z21.10.3–1998².

¹ AHRI Standard 1300P (I-P) & 1301P (SI) – Performance Rating of Commercial Heat Pump Water Heaters.

² ANSI Z21.10.3-1998 – American National Standard/CSA Standard for Gas Water Heaters.

Electric storage water heaters must conform to the following energy conservation standards¹ for standby loss:

$$\text{Maximum Standby Loss: } 0.30 + 27/V_m \text{ (\%/hr)}$$

where V_m is the measured volume. Water heaters having more than 140 gallons of storage capacity need not meet the standby loss requirement if the tank surface area is thermally insulated to R-12.5 or more.

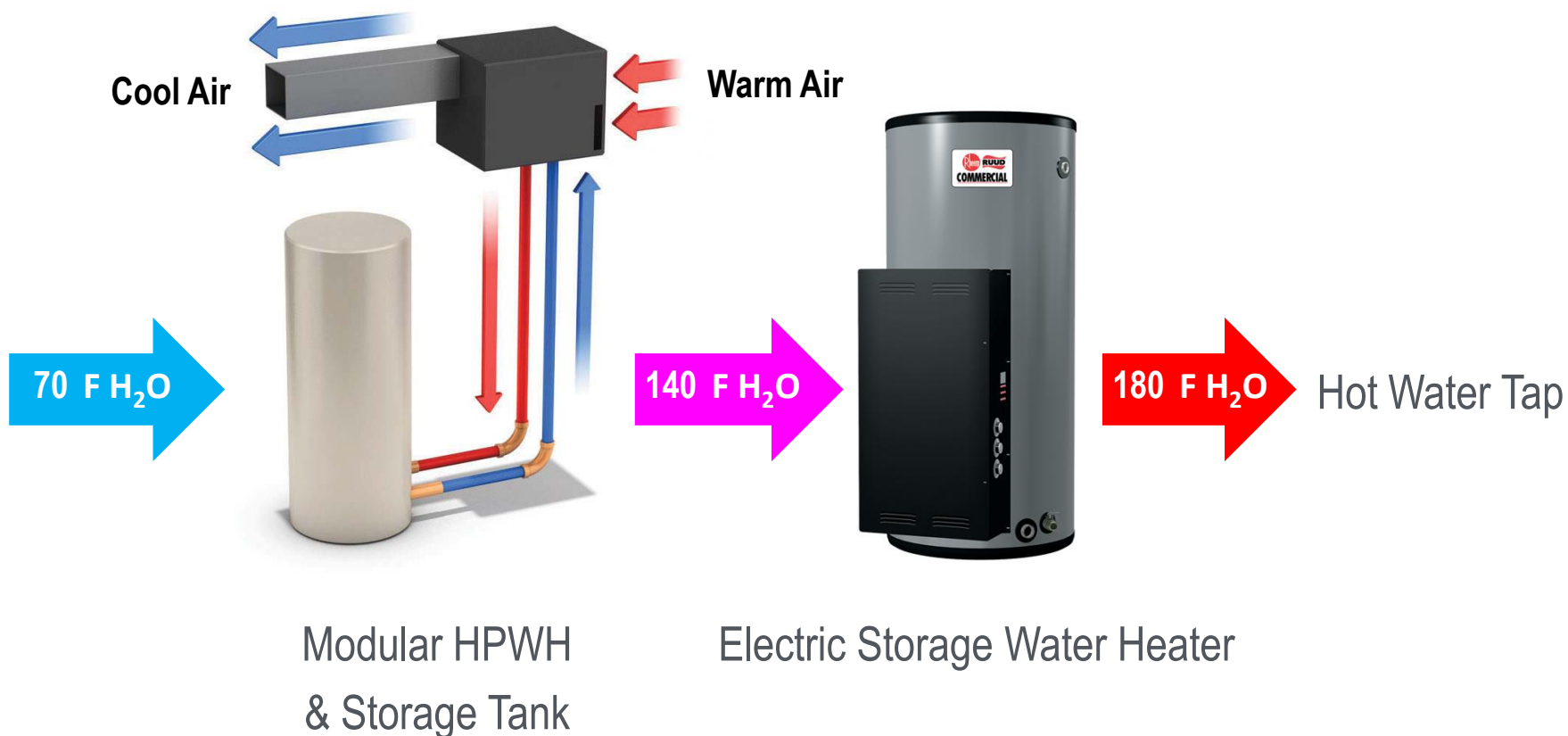
¹ As defined in: [Subpart G of CFR Part 431 – Commercial Water Heaters, Hot Water Supply Boilers and Unfired Hot Water Storage Tanks.](#)

AHRI has a voluntary energy efficiency certification program that independently measures and verifies manufacturer performance claims¹.

- Manufacturers participate to demonstrate independent verification of equipment and component performance claims.
- This program does not establish target energy efficiency levels.

¹ Zogg et al., “Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances ” (Navigant Consulting, Inc., 2009) .

HPWHs are typically combined with electric storage water heaters, to heat the water in a 2-stage process.



Navigant estimates an installed base of 600,000 commercial electric storage water heaters in the U.S.¹. Electric storage water heaters have been gaining market share.

- Major manufacturers include:
 - A.O. Smith / State Industries
 - Rheem
 - Bradford White Corporation
- 75% of sales are replacements; 25% of sales are new construction².

¹ Zogg et al., “Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances ” (Navigant Consulting, Inc., 2009).

² Per conversation with A.O. Smith.

Electric resistance storage water heaters can be replaced or retrofitted with HPWHs, resulting in 50% or more energy savings¹:

- HPWHs generally use electric-resistance heating for back up, when the heat-pump capacity is not sufficient to meet the water-heating demand.
- HPWHs using HFC refrigerants (i.e., R-134a) are commercially available in the U.S. with COPs of up to 4.2 (up to 70% energy savings over electric storage water heaters), with capacities ranging from 27,000-400,000+ Btu/h. The heat pump can generally deliver 140°F water without supplemental heating.
- In Japan, HPWHs are available with alternative refrigerants (i.e., CO₂), where residential models have reached a COP of 5.1. This technology could be an option for the U.S. commercial market in the longer term², but a significant development hurdle remains.

¹ Results vary with COP rating conditions, per Zogg et al., “Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances ” (Navigant Consulting, Inc., 2009).

² DOE has supported development of CO₂ HPWHs in the past.

- 1 » Technology Specification Overview
- 2 » Market Analysis
- 3 » Specification Analysis**

The CBEA specification will help push the market to the highest performing heat pump water heaters available today.

Tech Spec Efficiency Level in Perspective

Scale is efficiency in terms of COP



Compared to the commonly used electric resistance water heaters, HPWHs meeting this specification would save significant energy.

- To provide an example of energy savings, we examine a food services building (e.g. a fast food restaurant), with the following assumptions:
 - A HPWH achieves 50% savings over an electric storage water heater;
 - A typical restaurant uses 500 gallons of hot water per day;
 - The restaurant operates 365 days per year;
 - The water enters the water heating system at 60°F;
 - The hot water tap delivers water at 160°F;
 - Specific weight 8.27 lb/US gallon @ 110°F;
 - Specific heat 0.999 Btu/lb-°F @ 110°F;
 - Electricity costs \$0.10/kWh.

This results in a large operational cost savings and thus short payback.

